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THE NEW ENGLAND BOTANICAL CLUB

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SOME BOTANICAL STUDIES IN THE BLACK MESA REGION OF OKLAHOMA

C. M. ROGERS

A LAVA-CAPPED PLATEAU, about forty-five miles in length and varying from one to six miles wide, with the long axis lying generally from northwest to southeast, extends from southeastern Colorado through the northeastern corner of New Mexico into the tip of the Oklahoma panhandle. Most of this plateau lies in Colorado and New Mexico, where it is usually called the Mesa de Maya, while the easternmost part, which extends a short distance into Cimarron County, Oklahoma, is more commonly known as the Black Mesa.

For many years the Black Mesa region has been recognized as one of Oklahoma's most interesting botanically; yet, until recently, because of its distance from a center of education, very few details of the vegetation were known and herbarium material was practically non-existent. The author first visited the area in 1944, when he was a student new to Oklahoma, and with little knowledge as to which species were widespread or plentiful in the state. Yet in the one brief forenoon spent there, eleven species which reach their easternmost limit in Oklahoma in the Black Mesa region were collected, of which seven were then unknown in the state. There appeared to be ample reason why further study might be profitably undertaken. Intermittently, therefore, during the summers of 1947 to 1949 additional field work was conducted. A general account of the whole Mesa de Maya region may be found in an earlier paper (Rogers, 1953). The Oklahoma part is described briefly in the paragraphs that follow.

In the extreme northwestern corner of Cimarron County, the cutting action of the Cimarron River and its tributaries has resulted in the formation of many canyons and mesas, including the Black Mesa. It is this area, perhaps one hundred square miles in Oklahoma, that is referred to as the "Black Mesa region." Peninsula-like, the Black Mesa projects across the New Mexico boundary into the heart of this region, at a point about four or five miles south of the Colorado state line. It extends about three miles into Oklahoma and is approximately one mile wide here. The Black Mesa is the most conspicuous element of the region. Because of the layer of basalt which covers it to a depth of sixty to seventy feet or more here, the Mesa stands above the surrounding plains. On top of the Mesa is the highest elevation in Oklahoma, nearly five thousand feet.

The probable source of the lava is Piney Mountain or the Bar Seven-L Buttes, as it is locally known, a small hill near the center of the Mesa de Maya, about thirty miles westward in Colorado. Underlying the lava is the Dakota sandstone formation which, like the basalt, erodes vertically and results in steep talus-strewn slopes which rather abruptly merge with the plains below. The Cimarron River lies at the base of the south slope of the Mesa and Carrizo Creek, a tributary of the Cimarron, is on the north side. These two streams join at the eastern tip of the Black Mesa, about six hundred feet below its summit.

The nearly flat top of the Black Mesa is covered with a layer of soil varying from a few inches to several feet in depth, mostly clay containing pieces of weathered basalt, and apparently derived from the decomposition *in situ* of the lava. The upper slopes of the Mesa are strewn with blocks of basalt of all sizes, while downward transportation of detritus has produced outcrops of bare rock in many places, and considerable deposition of clay, sand, and gravel in others. The gentler lower slopes tend to have a more stable soil. The surrounding high plains are covered with soils derived from direct weathering of sandstone formations or from inwash of sands and gravels from the Rocky Mountains in recent geologic times.

Rainfall, based on a thirty year record kept at Kenton, one and one-half miles south of the Mesa, is about eighteen inches annually. Data from other nearby weather stations indicate

that from fifteen to twenty inches is the average annual precipitation over most of this region. Much of the rain comes as thundershowers, accompanied by large runoff. In this area, near the center of the dust bowl, the limited moisture available to the plants is probably the principal factor determining the type of vegetation that exists.

The Black Mesa region has three rather distinct vegetational types, the riparian, the prairie, and the foothill communities. Since the first two are widespread in Oklahoma, collections of plants in these communities add comparatively little to the total knowledge of the flora of the state. The stream-side plants here are principally *Populus deltoides*, *Salix exigua*, and *S. amygdaloides*. Though the Cimarron River and Carrizo Creek usually contain some water, most of the streams are dry except immediately following a rain and there is little chance for a hydrophytic vegetation to develop other than in a few pools, man-made ponds, seepage areas on the mesa sides, or other places where moisture can collect. There species of *Typha*, *Scirpus*, *Echinochloa*, and other wide ranging plants may be found.

The prairie grassland, found on the plains around the Mesa and on the level top, where mature soils have developed, must be considered the climax vegetation under the climatic conditions which now exist. The principal species are *Bouteloua gracilis*, *B. hirsuta*, and *Buchloe dactyloides*, with many other, mainly perennial, grasses and forbs. A dozen or fifteen species, such as *Muhlenbergia torreyi*, *Oryzopsis hymenoides*, *Verbena ambrosifolia*, and *Chrysothamnus nauseosus*, are restricted in their eastern distribution to the high plains and hence "enter" Oklahoma here. Otherwise, most of the plants of this community are also well known eastward throughout the state.

The Rocky Mountain foothill community is the one which is of particular interest to the author and others, for one can not help but be impressed by the abrupt change in the vegetation as the Black Mesa is approached from the nearly unbroken stretches of grassland to the east. The dominant plants are shrubs and small trees, mainly *Pinus edulis*, *Juniperus monosperma*, and *Quercus undulata*, with which are associated a variety of herbaceous species. The community is restricted to

the canyon and mesa sides where erosion, deposition, accumulation of moisture, shading, and associated factors produce a variety of conditions not duplicated in the plains region of Oklahoma. From sixty-five to seventy species, consequently, including all of the dominant plants in this community, are unknown eastward in the state. There are also many species for which Black Mesa collections are noteworthy within-the-state range extensions, principally species of the Wichita and Arbuckle Mountain areas.

The vegetation on the mesa sides shows much variation, both in density of growth and in kinds of plants. Some spots may be completely or nearly bare, while nearby is a growth of shrubs so dense as to be nearly impenetrable. Intermittently along the slopes, where a mature or stable soil has developed, prairie plants have invaded, as have some weedy plants whose distribution is not bounded by either foothills or plains. *Andropogon furcatus*, *A. saccharoides*, *A. scoparius*, and *Panicum virgatum*, abundant on the eastern plains, are more common on the mesa slopes than on the surrounding dry prairie.

The common woody or semi-woody plants on the Black Mesa, in addition to the species mentioned, are *Yucca glauca*, *Celtis reticulata*, *Ribes cereum*, *Cercocarpus montanus*, *Physocarpus monogynus*, *Prunus virginiana*, *Rubus deliciosa*, *Dalea formosa*, *Mimosa borealis*, *Ptelea trifoliata*, *Rhus trilobata*, *Forsellesia planitierum*, *Vitis longii*, several *Opuntias*, mainly *O. imbricata*, *Brickellia brachyphylla*, *B. californica*, and *Pericome glandulosa*. A few individuals of *Pinus ponderosa*, wide ranging at low altitudes in the Rocky Mountains, are also found near the Black Mesa. In rocky crevices are such ferns as *Cheilanthes eatoni*, *C. feei*, *Notholaena sinuata*, *N. standleyi*, *Pellaea atropurpurea*, and *Woodsia oregana*, as well as *Selaginella densa*, while a few of the other herbaceous plants which are characteristic of or restricted to this habitat, filling in under and between the woody species, are the grasses *Bromus anomalus* var. *lanatipes*, *Oryzopsis micrantha*, *Setaria macrostachya*, *Stipa neomexicana*, *S. scribneri*, and *Trichachne californica*, and also the following herbs, *Paronychia sessiliflora*, *Lesquerella ovalifolia*, *Psoralea tenuiflora*, *Asclepias macrotis*, *Mentzelia oligosperma*, *Gilia laxiflora*, *Onosmodium occidentale*, *Cryptantha thyrsoiflora*, *Erigeron nudiflorus*, and *Zinnia grandiflora*.

While most of the species characteristic of the Mesa slopes are eastern outliers of the Rocky Mountain foothills, a few appear to be more appropriately considered a part of the flora which lies to the south and west of the Black Mesa. Some of these are *Aristida arizonica*, *A. divaricata*, *Muhlenbergia arenicola*, *M. porteri*, *Enneapogon desvauxii*, *Allionia incarnata*, *Mimosa borealis*, *Ditaxis laevis*, *Asclepias involucrata*, *A. macrotis*, and *Verbena plicata*, all of which appear to reach the northeastern edge of their range here. In some instances the Black Mesa collections are many miles from the nearest known station. Further field work may close the gaps in the ranges of these species, but the Black Mesa region, for the present, must be considered a relict area for certain southwestern plants.

During the past few years from thirty-five to forty species from the Black Mesa region have been added to the known flora of the state (see chiefly Waterfall 1949, 1950a, 1950b). Some species, which appear not to be included in Waterfall's recent (1952) list of the plants of the state, were collected by the author on or about the Black Mesa. Among them are the following. The numbers cited are in each case the author's. Voucher specimens are in the herbarium of the University of Michigan.

SELAGINELLA Densa Rydb. This plant is fairly frequent on the rocky slopes of the Black Mesa, where 4767 was collected on July 9, 1947. The species has been reported from Baca County, Colorado, just north of Cimarron County, but apparently has not been recorded for Oklahoma.

ARISTIDA ARIZONICA Vasey. This grass ranges from southern Colorado to southern Texas and Arizona. Chase, in Hitchcock's Manual of Grasses (ed. 2. 1950) and Waterfall, in his catalogue, fail to record this species from Oklahoma, although Featherly (Manual of the Grasses of Oklahoma: 43. 1946) states that it has been collected in Roger Mills County. Specimens from the Black Mesa, with spikelets very near the minimum size for this species, are 5061, collected on the slope of the Black Mesa, 3 miles north of Kenton, July 28, 1947, and 6454, from one mile southwest of Kenton, September 9, 1948.

ARISTIDA DIVARICATA H. & B. This grass is omitted from Waterfall's Catalogue, but is recorded for western Oklahoma by both Featherly (*op. cit.*: 41) and Chase (*op. cit.*: 472). An additional record is 6909, August 1, 1949, from 5 miles east of Kenton.

ENNEAPOGON DESVAUXII Beauv. This grass, better known as *Pappophorum wrightii*, appears to be quite uncommon in the Black Mesa region. Only a few plants were seen, from which 6460, on a rocky slope 1 mile southwest of Kenton, September 9, 1948, and 6922, on the side of

the Black Mesa, north of Kenton, were taken. The distribution of this plant has been known from Utah to Texas and southward, so that the Oklahoma stations are at the northeastern edge of its range.

LEPTOCHLOA DUBIA (HBK) Nees. A northward extension of range within the state is represented by 6411, from the side of the Black Mesa, north of Kenton, September 7, 1948. Chase (*op. cit.*: 492) includes the state within the range, and Featherly (*op. cit.*: 28) records it from Comanche and Murray Counties.

POA FENDLERIANA (Steud.) Vasey. This grass, widely distributed in the foothill and mesa regions of the Rocky Mountains, has been reported by Rydberg (*Flora of Colorado*: 46-47. 1906), including *P. longipedunculata* and *P. brevipaniculata*, and by Harrington (*Manual of the Plants of Colorado*: 58. 1954) from a number of localities in southeastern Colorado, so that this extension eastward into Oklahoma is not unexpected. It is represented here by 5608, collected on a rocky hillside 3 miles east of Kenton, April 24, 1948.

SETARIA MACROSTACHYA HBK. This species has been reported by Featherly (*op. cit.*: 90) from Payne County. A suitable habitat is unlikely there and since Waterfall omits this grass from his catalogue, the report may be erroneous. The plant is frequent on the mesa sides, 4785 having been collected on the slope of the Black Mesa north of Kenton, July 10, 1947. Other collections are recorded by Harrington (*op. cit.*: 112) from Baca County, Colorado, adjacent Cimarron County on the north.

BRAYULINEA DENSA (H. & B.) Small. This unexpected find was collected as 5935, June 10, 1948, and again as 6910, August 1, 1949, about 3 miles east of Kenton. Kearney and Peebles (*Arizona Flora*: 268. 1951) give the range as western Texas to Arizona and southward, indicating that the Black Mesa collections extend this some distance northward. A number of plants were found, all restricted to a small grassland area where the dominant plant was the mesquite, *Prosopis juliflora* var. *glandulosa*, also a southwestern plant reaching the limit of its range here in the Black Mesa region.

FALLUGIA PARADOXA (D. Don.) Endl. This rosaceous shrub was collected as 5931, June 10, 1948, near the former U. S. Highway 64 at the Old Santa Fe Trail marker, between Boise City and Kenton. Only a plant or two were seen, and can scarcely be said to have been established in the area. Perhaps until additional evidence is secured that it is maintaining itself, this species should not be admitted to the state flora. This station is not too far east of the present known limit of the species in New Mexico and it is likely that more plants may be found within the state.

ASTRAGALUS HALLII A. Gray. One of the duplicates of 5691, collected along the upper slopes of the Black Mesa, north of Kenton, May 16, 1948, was determined to be this species by C. L. Porter. On the basis of this determination the species is included in the state flora. Other collections of this species in southeastern Colorado fill in the gap between the Black Mesa and the Rocky Mountains, from which it has long been known.

ASTRAGALUS LOTIFLORUS Hook. Stemen and Myers (Oklahoma Flora: 247-248. 1937) list this species from the "plains" of Oklahoma, although Waterfall omits it from his catalogue. Two collections from near the highway between Boise City and Kenton, 5605 about 10 miles southeast of Kenton, and 5719, about 8 miles east of Kenton, both determined by C. L. Porter, reinstate this species in the flora of the state.

DITAXIS LAEVIS (Torr.) Heller. This southern species has been previously reported only as far north as western Texas and southern New Mexico. The present specimens were collected as 4751 on the slope of the Black Mesa north of Kenton on July 9, 1947. These as well as other specimens of this species which were examined resemble *D. humilis* in characters other than pubescence and Pax (in Engler, Das Pflanzenreich, 57 (IV, 147, VI): 75. 1912) indicates that this is the main difference between them. If true it is very doubtful whether the plant deserves specific rank. *D. humilis* is also found in the Black Mesa region and is the more common of the two species.

CORYPHANTHA DESERTI Britt. & Rose. This western species of cactus is represented in the flora of Oklahoma by 5992½, collected atop the Black Mesa north of Kenton, June 13, 1948. This, a living plant, was sent to E. U. Clover, who determined it to be this species.

OENOTHERA ENGELMANNI (Small) Munz. Munz (Amer. Journ. Bot. 18: 316. 1931) cites specimens of this species from Texas and New Mexico, while Harrington (*op. cit.*: 396-397) records it from southeastern Colorado also. A short extension eastward is 4684, collected in the prairie about 14 miles west of Boise City, somewhat outside the Black Mesa region, but near enough to warrant mention here.

ASCLEPIAS INVOLUCRATA Engelm. This southwestern species was collected as 1068, during the author's first trip to the Black Mesa, June 5, 1944, on the high plains 18 miles northwest of Boise City. Since that time, the plant has been collected twice in nearby southeastern Colorado. One of these specimens was verified as this species by R. E. Woodson. The plant is nowhere common, but is found almost throughout the grassland area in the Black Mesa region.

CRYPTANTHA THYRSIFLORA (Greene) Payson. This perennial is a conspicuous and frequent herb on and about the Black Mesa and may inadvertently have been omitted from earlier lists. It is represented by several collections, the first of which, 2083, was collected on the Black Mesa, June 5, 1944.

ANTENNARIA PARVIFOLIA Nutt. Plants keying to this species were observed in several localities in the Mesa de Maya region, but in only one area in Oklahoma, about 8 miles east and 7 miles north of Kenton, near the Oklahoma-Colorado state boundary, where it was frequent in protected places on rocky slopes. There, 6189 was collected on July 6, 1948, quite past the flowering stage.

CIRSIIUM UNDULATUM (Nutt.) Spreng. This species has been reported several times from Oklahoma. Material keying to *C. undulatum* was

found throughout the Mesa de Maya Region, of which 4826 was collected atop the Black Mesa north of Kenton on July 11, 1947.

ERIGERON FLAGELLARIS A. Gray. Though recorded for Colorado and New Mexico, as well as other Rocky Mountain states, Oklahoma has not been included in the range of this species. Only a few plants were found, these near the Cimarron River north of Kenton where 5704, verified by S. F. Blake, was collected May 16, 1948. These probably developed from seeds brought down by the river from further west where the species is more common.

Of the nearly six hundred species collected by the writer over the whole Mesa de Maya, approximately five hundred were found, or could be found in Oklahoma. The remaining one hundred, still unknown in the state, came from adjacent New Mexico and/or Colorado. Of these some grow near the western end of the Mesa de Maya, thirty miles or more from the Oklahoma state line and up to 1800 feet higher in elevation, and can scarcely be expected within the state. A number, however, were collected within twenty miles of the state line, in habitats almost identical to those existing on and about the Black Mesa. These should be looked for within the state. Among the more interesting of these species are *Notholaena fendleri*, *Muhlenbergia arenacea*, *Stipa viridula*, *Ribes leptanthum*, *Opuntia phaeacantha*, *O. rhodantha*, *O. schweriniana*, *Oenothera flava*, *Swertia coloradensis*, *Asclepias uncialis*, *Lobelia cardinalis*, *Artemisia frigida*, *Brickellia grandiflora*, and *Pericome caudata*.

There are still many kinds of plants to be collected in the Black Mesa region. Each collecting trip yields additional species. The area, though small, is varied, and every newly explored canyon or mesa may and frequently does contain plants which are not known to exist in the state.

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THE STATUS OF SOME AMERICAN SPECIES OF
MYRIOPHYLLUM AS REVEALED BY THE
DISCOVERY OF INTERGRADE MATERIAL
BETWEEN *M. EXALBESCENS* FERN.
AND *M. SPICATUM* L. IN
NEW JERSEY

BERNARD C. PATTEN, JR.

THIS paper arises out of a coöperative project between the Forests and Parks Section of the New Jersey Department of Conservation and Economic Development and the Botany Department at Rutgers University, the State University of New Jersey. The project was initiated in order to study the ecology and life history of a dominant aquatic weed in several lakes of northern New Jersey and to suggest, if possible, intelligent control procedures. This weed has been identified for Lake Musconetcong as *Myriophyllum exalbescens* Fern. (Renlund 1950, p. 169).

The present study was undertaken when the writer noted that although the plants in Lake Musconetcong keyed readily to *M. exalbescens* in the eastern manuals (Fassett 1940, Muenscher 1944, Fernald 1950 and Gleason 1952), they did not conform strictly to the descriptions of this species. This material has a greater number of capillary leaf divisions than does *M. exalbescens* and displays a decided protrusion of the lowermost floral bracts beyond the fruits. Fernald (1919) had used both of these characters to separate *M. exalbescens* from *M. spicatum* L. (1753) in his original description of the former:

. . . aquatic herb; the stem glabrous, leafy, simple or branching, purple, in the dried state becoming white; leaves verticillate, rarely in 3's, commonly in 4's, 1.2–3.0 cm. long, with 7–11 pairs of capillary flaccid or barely a little rigid segments [this range later became 6–11 pairs: Fernald 1950, p. 1073]; spikes terminal, almost naked, the flowers verticillate; the lower pistillate, the upper staminate, sessile; bracts rarely equalling the fruit, spatulate-obovate or oblong-cochleiform; the lower serrate, the upper entire; bracteoles ovate, entire, brown-margined, 0.7–1.0 mm. long; petals oblong-obovate, concave, 2.5 mm. long; stamens 8; anthers oblong, 1.2–1.8 mm. long; fruits subglobose, very slenderly 4-sulcate, 2.3–3.0 mm. long; the merocarps rounded on the back, smooth or rugulose.

According to Fernald, "*M. exalbescens* [had] always passed in America as *M. spicatum* L. The latter species of Eurasia, however, differs from the American plant in several characters:

the principal leaves of the primary stems have 14–21 pairs of rigid slenderly linear divisions; the bracts are rhombic-obovate; the bractlets are sub-orbicular or reniform, broader than long, and distinctly shorter than in most of *M. exalbenscens*, 0.5–0.8 mm. long; and the linear anthers tend to be longer, being 1.8–2.2 mm. in length. In *M. exalbenscens*, furthermore, the dried stems very strongly tend to become white, although this change is not always noted; in *M. spicatum*, however, the old herbarium specimens still retain a fulvous or olivaceous tone in the stems."

Concerning the floral bracts, Fernald (1919, p. 123) implies that they only occasionally exceed the fruits in some varieties of *M. spicatum*. Hegi (1926, p. 901), however, states that they are typically as long as or exceeding the flowers. This would appear, therefore, to be an additional valid character upon which to separate the two species.

As a further point of separation, Hultén (1947, pp. 1159–1160) stated that winter buds never develop in *M. spicatum* while such buds are often prominent in *M. exalbenscens*.

A summary of the published differences between these two species is provided on Table I.

TABLE I

Comparison of characters used to separate *M. exalbenscens* from *M. spicatum* in Series I and Series II material from New Jersey

| Character | <i>M. spicatum</i> | <i>M. exalbenscens</i> | Series I | Series II |
|-------------------------------------|-----------------------------|---------------------------------------|--------------------------|--|
| 1—shape of floral bracts | rhombic-obovate to elongate | spatulate-ovate or oblong-cochleiform | ovate to elongate | spatulate-ovate |
| 2—relative length female bracts | longer than fruits | rarely equalling fruits | exceeding fruits | rarely equaling and never exceeding fruits |
| 3—shape of bracteoles | suborbicular or reniform | ovate | ovate | ovate |
| 4—dimensions of bracteoles | broader than long | longer than broad | both | both |
| 5—dried stem color | olivaceous or fulvous | whitened | whitened to olivaceous | whitened to fulvous |
| 6—winter buds | absent | present | reduced* | present |
| 7—number of pairs of leaf divisions | 14–21 | 6–11 | 7–20 | 4–12 |
| 8—length of bracteoles | 0.5–0.8 mm. | 0.7–1.0 mm. | ♂: 0.5–1.2 ♀: 0.6–1.0 | ♂: 0.5–1.3 ♀: 0.7–1.1 |
| 9—length of anthers | 1.8–2.2 mm. | 1.2–1.8 mm. | 0.9–2.1 mm. | 1.2–2.0 mm. |

In the same paper containing the description of *M. exalbescens*, Fernald also described *M. magdalense* (later corrected to *M. magdalenense*: Fernald 1924). This species very closely resembled *M. exalbescens* except for the possession of "fruit so very unlike that of the latter species or of the old world *M. spicatum*." This appears dubious since "the material of *M. magdalense* [was] mostly immature, only one plant being found with good fruit," and two other species, *M. exalbescens* and *M. verticillatum* var. *intermedium* Koch, were present in the vicinity so that the possibility of hybridization was genuinely extant. *M. magdalenense* was described as follows:

Similar to *M. exalbescens*; the stem branching, becoming white when dried; leaves mostly in 4's, 1–2 cm. long, with 3–7 pairs of capillary flaccid segments 0.5–1.3 cm. long; the upper emergent ones elongate-ob lanceolate or linear, short-pectinate or subentire; spikes terminal, with the rachis filiform; flowers verticillate, the lower pistillate, the upper staminate, sessile; bracts elongate, linear oblanceolate, conduplicate, up-curved at the end, entire or the lower pectinate, 0.3–1 cm. long; bractlets ovate, 0.6–0.8 mm. long; petals ovate-oblong, concave, 1.5 mm. long; stamens 8; anthers oblong, 1.5 mm. long (immature); fruits subglobose, 3 mm. long, very broadly 4-sulcate; the merocarps with rounded rugose backs.

Chapman (1889, p. 143) cited the description of a Floridian species, *M. laxum* Shuttl., which is obviously very closely related to the two species of Fernald:

. . . stem long, slender; leaves four in a whorl; the floral ones reduced to minute nearly spatulate bracts, shorter than the flowers, which thus formed an interrupted almost naked spike; fruit roughened with minute warts, with the lobes obtuse.

Small (1933, pp. 954–955) supplies additional information on this species:

Stamens 8; corolla deciduous. Leaves in 4's; blades of the approximate submersed ones with 3–7 pairs of capillary segments; those of the floral ones spatulate; petals elliptic, 2.3–3.0 mm. long; anthers linear to narrowly elliptic, about as long as the filaments; fruit ovoid-globose, about 1.5 mm. long; carpels minutely warty.

In addition, Grout (1896, p. 11) described the bractlets as small, lanceolate and hyaline.

From a careful comparison of these descriptions, it would appear that these four species are closely related as a single complex whose geographic segments have differentiated in very small degrees along different pathways away from the common stock. The question arising is whether or not these segments

have achieved "truly" specific status. It is the purpose of the subsequent sections of this paper to provide an answer to this question for *M. exalbescens* through a comparison of material from New Jersey coupled with the use of herbarium and literature resources.

Two series of collections from various locations in New Jersey were made. Series I contained specimens resembling the material of Lake Musconetcong in having a large number of leaf divisions and the lowermost floral bracts exceeding the fruits. Series II comprised more typical *M. exalbescens* in having shorter bracts and fewer leaf segments. The Series I material was collected at the following locations: 1) A fertile population from Lake Musconetcong, Morris and Sussex Counties. 2) Lake Lakawanna, several miles northwest of Lake Musconetcong in Sussex County; fertile. 3) The Delaware and Raritan Canal, Middlesex County; fertile. 4) Johnson Park Pond (Upper), several hundred yards from the third site; fertile. Series II material was collected from 1) Gardner's Pond, Sussex County; fertile. 2) Wolf Lake, less than a mile above Lake Lackawanna; sterile. 3) Wright's Pond, located above and connecting with Wolf Lake; sterile. Of interest is the fact that the latter two locations flow into Lake Lackawanna, yet this lake has only Series I material represented. The material which was sterile was grouped into Series II on the basis of the small number of leaf divisions alone since floral bracts were lacking.

There are only two additional species of *Myriophyllum* known to the writer in the Sussex-Morris County area from which most of the above collections were made. *M. heterophyllum* Michx. is very widespread. The material from Wolf Lake and Wright's Pond can be separated from it in the sterile condition, even though the number of leaf divisions is similar, by the whitened stems and the large winter buds of the former. *M. verticillatum* (var. *pectinatum* Wallr.) is represented by a single sterile population inhabiting the shallow ecotonal waters of a cove in Lake Musconetcong.

Using the qualitative and quantitative premises for the separation of *M. exalbescens* from *M. spicatum* (Table I), the two New Jersey series were carefully compared. Quantitative

information was obtained by counting or measuring random samples of each of the structures indicated. The frequency distributions obtained by so-doing were subjected to statistical analyses to determine the degree of significance of any differences observed between means of the two series. Table I compares the results and Table II provides a summary of the statistical findings. In the discussion following, each character is numbered to correspond with similar numbers in the tables to facilitate reference by the reader.

TABLE II
Summary of statistical analyses of quantitative
characters in Series I and Series II material

| <i>Series</i> | <i>n</i> | <i>r</i> | <i>M</i> | σ | σ/\sqrt{n} | <i>D/E_d</i> | <i>t_s</i> |
|--------------------------------------|----------|----------|----------|----------|-------------------|------------------------|----------------------|
| 7—Number of pairs of leaf divisions | | | | | | | |
| I | 538 | 7-20 | 14.94 | 11.66 | 0.50 | 7.034 | 1.95996 |
| II | 592 | 4-12 | 8.23 | 10.10 | 0.41 | | |
| 8a—Length of male bracteoles (mm.) | | | | | | | |
| I | 91 | 0.5-1.2 | 0.964 | 3.03 | 0.32 | 0.016 | 1.95996 |
| II | 60 | 0.5-1.3 | 0.978 | 3.56 | 0.46 | | |
| 8b—Length of female bracteoles (mm.) | | | | | | | |
| I | 90 | 0.6-1.0 | 0.889 | 3.32 | 0.35 | 0.025 | 1.95996 |
| II | 72 | 0.7-1.1 | 0.913 | 4.62 | 0.54 | | |
| 9—Length of anthers (mm.) | | | | | | | |
| I | 576 | 0.9-2.1 | 1.70 | 12.10 | 0.50 | 0.048 | 1.95996 |
| II | 142 | 1.2-2.0 | 1.65 | 6.97 | 0.58 | | |

n equals the number of variates included in each sample; *r* is the range in the magnitude of each character; *M* is the mean of each character as calculated by the assumed mean method; σ is the standard deviation; σ/\sqrt{n} is the standard error; *t_s* signifies Fisher's *t*-value at 5% probability (see any statistics text for a table of *t*); *D* is the difference between the means of the two series; *E_d* is the standard error of this difference (calculated from the expression $E_d = \sqrt{\sigma/\sqrt{n_1} + \sigma/\sqrt{n_2}}$). If *D/E_d* exceeds *t_s*, the observed differences between the means of the two samples are significant. Such is the case only in the comparison of number of pairs of leaf divisions in the two series.

1. *Shape of floral leaves.* The uppermost (staminate) bracts were similar in both series: spatulate, both ovate and obovate; margins usually denticulate but often entire. The lowermost (pistillate) bracts differed: elongate and serrate to completely pinnate in Series I; spatulate-ovate and serrate in Series II. No rhombic contours were encountered.

2. *Relative length of lowermost bracts.* Almost always exceeding the fruits in Series I; rarely equalling and never exceeding the fruits in Series II.

3. *Shape of bractlets.* Ovate in both series.

4. *Dimensions of bractlets.* Some were broader than long and others were longer than broad in both series.

5. *Dried stem color.* Examination of sheets at the New York Botanical Gardens indicated this character to be of little utility to the average observer. There was free intergradation of stem color in both American and continental material. The dried stems of Series I material are whitened to olivaceous; those of Series II whitened to fulvous.

6. *Winter buds.* Turions are very prominent in Series II material, obtaining several centimeters or more in length. They are present in Series I specimens but are very much smaller, being usually only a centimeter or less. Furthermore, those of Series I are bright red through stramineous to light green whereas those of Series II are deep green.

7. *Number of pairs of capillary leaf segments.* The sheets at the New York Botanical Gardens supported Fernald's contention that *M. exalbescens* possessed fewer pairs of leaf divisions than *M. spicatum*. American material had 5-12 pairs and Eurasian 10-21 pairs, with the exception of that from Scandinavia and a single specimen from the Soviet Union which resembled American specimens more in this regard. The Series I plants had 7-20 pairs of divisions with a mean of nearly 15; the Series II material had only 4-12 pairs with a mean of 8.23. The analysis (Table II) indicated these differences to be significant: D/E_d was greater than t_5 . This significance was at less than one per cent probability indicating that less than one variate in one-hundred from either series would intergrade with those from the other series.

8. *Length of bracteoles.* Although Fernald did not treat separately the bractlets of the two sexes, this was done here to eliminate that factor as a source of variability. None of the differences was significant. There was, however, a non-significant degree of sexual dimorphism in both series, the male bractlets being somewhat longer than those of the pistillate flowers.

9. *Anther length.* No significant differences existed between the means of the two series.

Reference to Table I allows ready comparison of the results outlined above with the published descriptions of the same characters for *M. spicatum* and *M. exalbescens*. Both series of New Jersey material are seen to intergrade between the two species. Although a specific character may be skewed in the direction of one of the species, it is generally influenced by the other. For example, the bracteoles of *M. spicatum* are described as shorter than those of *M. exalbescens*, and although the Series I bracteoles are insignificantly shorter than those of Series II, the degree is less than described.

Thus both series display an admixture of characteristics from both species, and although Series I leans more toward *M. spicatum* and Series II the opposite, the conclusion must be that none of the New Jersey material sampled is strictly either of the described species.

Three possibilities exist by which to explain the status of this New Jersey material:

1. *That the indigenous M. exalbenscens hybridized with another indigen to produce a similitude to M. spicatum.* Although the potential for this occurrence is extant in the presence of *M. heterophyllum* and *M. verticillatum*, the writer is of the opinion that the production of a hybrid so closely resembling an existing species from another continent is clearly beyond probability. However, it should be mentioned that *M. verticillatum* is a highly variable circumboreal species so that many present species, including *M. spicatum* and *M. exalbenscens*, could actually be well-differentiated varieties of a vast *M. verticillatum* complex. Indeed, Gmelin believed *M. verticillatum* and *M. spicatum* to be one and the same species, and Perrot (1900) provided a degree of anatomical evidence which supported this view (p. 202). The writer shares this point of view. After flowering of the Series I material in Lake Musconetcong the lowermost floral bracts often grow outward and, in basipetal succession, assume the fully-dissected character of normal submerged leaves or of the pinnately-divided floral leaves of *M. verticillatum*. It is therefore possible that the Series I plants are actually derived from *M. verticillatum* or a combination of this species with *M. exalbenscens*. Since, however, conclusive evidence in support of such broad considerations is lacking, this hypothesis must be regarded as the least valid of the three possibilities.

2. *That M. spicatum became introduced and intergraded with the indigenous M. exalbenscens.* Lake Musconetcong was originally impounded eleven decades ago to supply water for the trans-state Morris Canal. There existed at one time direct connection between canal and lake. This canal and the Delaware and Raritan Canal in central New Jersey were both used in the transportation of goods, probably including continental imports, across the state. Thus there existed in previous time two possible sites of introduction of *M. spicatum* from Eurasia. There is, however, no proof to support this hypothesis and the following evidence tends to negate it. The *M. spicatum*-like Series I plants are not widespread in the Delaware and Raritan Canal occurring, to the author's knowledge, only at the collection site. The Morris Canal is now abandoned, only discontinuous seg-

ments of it remaining submerged. Of these areas only one, into which Lake Musconetcong flows directly, is known to contain a sparse population of Series I material. Thus if *M. spicatum* was introduced into either of the canals, it did not there meet with the widespread success characteristic of the Series I plants in other sites where it occurs.

3. *That the New Jersey material represents intergrades between geographically disjunct segments of a circumboreal M. spicatum-M. exalbens complex.* The distribution of such a complex is depicted roughly in Figure 1. Under this hypothesis two possibilities prevail: 1) that complete separation of the two species was never achieved and that intergrades exist at the peripheries of the overlapping ranges, or 2) that subsequent to complete disjunction (which permitted the differentiation of Eurasian and American populations) reunion was achieved and intergrade material resulted. The latter is similar to hypothesis number two above, only broader in aspect. The writer favors hypothesis number three because of the following direct and indirect evidences.

Since Fernald's separation of *M. exalbens* from the complex, various American investigators working in various regions have failed to recognize it either through unfamiliarity or because their material would not permit them to do so. House (1924), working in New York, listed the species of that region as *M. spicatum*, making only casual note of Fernald's synonymy. Wiegand and Eames (1925), however, working in the Cayuga Lake Basin, did recognize the distinction. Jepson (1925), working with limited collections from California, assigned Fernald's species to the varietal status, *M. spicatum* var. *exalbens* Jeps. Other western workers, Peck (1941) in Oregon and Kearney and Peebles (1942) in Arizona, recognized *M. exalbens* and merely mentioned the synonymy of Jepson. Tidestrom (1925) in Utah and Nevada, Tidestrom and Kittell (1941) in Arizona and New Mexico, Pepoon (1927) in Illinois, and Rydberg (1932) in the Plains and Prairie regions all list *M. spicatum* for their respective regions. They do not, however, list synonymy. Deam (1940) listed *M. exalbens* for Indiana. Standley (in Cooper 1930) referred Alaskan material to *M. spicatum*. Hultén (1947), also working in the Alaskan region, assigned *M. exal-*



Figure 1. Condensed equal area sinusoidal projection of the world. The land areas which are unblacked represent the approximate range of the *M. spicatum-M. exalbesens* complex after Fernald 1919, 1950, Hegi 1926 and Hultén 1947. Hultén cites the occurrence of *M. spicatum* in South America and Australia whereas Hegi stated its absence from both these continents.

bescens to a subspecies, *M. spicatum* subsp. *exalbescens* Hult., because "... the difference between the types is ... so small that I prefer to regard *M. exalbescens* as a geographical race of *M. spicatum*." Finally, Fernald (1919), in his citations of collections, notes some Colorado material with unusually elongate bracts, a condition relating more to *M. spicatum* than to his species.

In Figure 1 the approximate locations of those citations above which appear to be in dispute with Fernald's separation are denoted as circles on this continent. It is obvious that these points lie in areas which can be considered peripheral in relation to the whole range of *M. exalbescens*.

To attest further to the variability of *M. spicatum*, one needs only to consult European floras such as that of Hegi for a list of several varieties. Indeed, Lange (1887) described one, *M. spicatum* var. *capillaceum* Lange, for Greenland which is quite adjacent to the range of *M. exalbescens*. It is unfortunate that this work was not readily available for comparison with the species considered earlier, especially since Fernald cited a specimen of *M. exalbescens* from Greenland (1919, p. 120).

To further support the implied variability of the complex, sheets from the collections at the New York Botanical Gardens were examined. The number of pairs of leaf divisions and stem color were given emphasis since other characteristics do not show well in the dried material. Three specimens labeled *M. spicatum* var. *exalbescens* Jeps. were examined: 1) No. 1402, 1477. 1941. A. H. Holmgren, Nevada. 2) No. 4910. 1939. C. L. Hitchcock, Oregon (Deschutes River). 3) No. 5139. 1939. I. W. Clokey, California (Lake Arrowhead). These specimens could not be separated from *M. exalbescens* Fern. by superficial characters.

Three specimens of Scandinavian material were examined: 1) 1869. Prof. Boeck, Norway; labeled simply "Myriophyllum" (placed in *M. spicatum* file). This specimen resembled *M. exalbescens* in every superficial character: whitened stem, short floral bracts and 6-8 pairs of leaf segments. 2) No. 823. 1913. E. of Hälström, Sweden (Lake Torankijärvi); labeled *M. spicatum*; possessed whitened stem and 6-7 pairs of leaf divisions. 3) 1882. Thedensis, Sweden (Stockholm); whitened stem and 8-10 pairs of leaf segments.

Ten specimens of far-eastern material were examined: 1) No. 18420. 1928. China (Univ. of Nanking); labeled *M. spicatum*; fulvous stem and 16–21 pairs of leaf divisions. 2) No. 807. 1933. China; whitened stem, elongate pistillate bracts, up to 27 pairs of leaf divisions. 3) No. 3337. 1903. Leg. D. Litvinov, Manchuria (Sangari River); labeled *M. verticillatum* because of prominent elongate lowermost bracts; specimen the precise image of Series I material from New Jersey. 4) No. 3412. 1902. Litvinov, west. Manchuria (Sta. Chingis-Khan); label and characteristics same as above specimen. 5) No. 9669. 1936. W. Koelz, India (Shigar, Baltistan); labeled *M. spicatum*; two specimens duplicating those of N. J. Series I. 6) No. 8959. 1936. India (Dal Lake in north-western Himalayas, Srinagar, Kashmir); labeled *M. spicatum*; characters same as sheet above. 7) No. 6752a. 1922; 8) No. 399a. 1913; 9) No. 10205a. 1929. All three by R. R. Stewart, Dal Lake; characters same as No. 8959 above. 10) No. 895. 1927. U.S.S.R.; labeled *M. spicatum*; characterized by whitened stem and only up to eight pairs of leaf divisions. Additional material examined from the interior of Eurasia showed no variation from typical *M. spicatum*.

These sheets indicate for the most part an *M. exalbenscens* influence in both Scandinavia and the Far East, both of which regions are peripheral in relation to the whole distribution of *M. spicatum*. The approximate locations of the above collection sites appear in Figure 1 as circles on the Eurasian continent.

The distribution of all the circles in the figure suggests definite intergrade areas between *M. spicatum* and *M. exalbenscens*. Thus the third hypothesis appears to be fairly well substantiated and there is indicated a variable circumboreal complex which it seems desirable to treat nomenclaturally as a single species.

It would not seem expedient to carry the present classification since this necessitates the naming of all the kinds of intergrades which might occur, a task with plural limitations. There exists a possibility that *M. exalbenscens* Fern. and *M. spicatum* var. *capillaceum* Lange are the same since both of these descriptions were based, in part only in the former instance, upon material from Greenland. This would invalidate Fernald's name in the varietal category through precedence. However, the results of this study indicate a subspecific rank for this taxon and the

name may be written *M. spicatum* subsp. *exalbescens* (Fern.) Hult. Intergrades can then be referred to this taxon or to *M. spicatum* L., depending upon which a particular collection more nearly resembles. Excluding from consideration Eurasian variations which may already have been treated but which the writer is in no position to discuss, the Series I American material and the far-eastern intergrade material belong, under this classification, to *M. spicatum* L. The Series II material, other American material, and probably also the Scandinavian intergrades are to be taken as *M. spicatum* subsp. *exalbescens* (Fern.) Hult.

The writer wishes to acknowledge the aid of the following individuals who have critically read and appraised the manuscript, and have provided suggestions for its improvement: Drs. E. T. Moul and M. F. Buell of Rutgers University, Dr. J. M. Fogg Jr. of the University of Pennsylvania and Dr. A. H. Wahl of Pennsylvania State College.

Sheets of the New Jersey material analyzed in the study are filed in the Chrysler Herbarium at Rutgers University.

SUMMARY

1. This study was undertaken because of the discovery that some of the material of *M. exalbescens* Fern. bore a superficial resemblance to the Eurasian counterpart, *M. spicatum* L.

2. The descriptions of four species are provided 1) to indicate their close similarity, 2) to emphasize the variable nature of the group in general, and 3) possibly to question several of the descriptions.

3. Two series of New Jersey material, one resembling typical *M. exalbescens* and the other *M. spicatum*, were compared to determine their relation to one another and to the two species which they resembled. They were indicated to be intermediate between these species.

4. Three hypotheses were propounded to explain this intergradation. The one selected as best-supported was based upon evidence favoring the consideration that *M. exalbescens* is a geographical variant of a circumboreal *M. spicatum* complex.

5. Due to the indicated probability of widespread intergradation, it was deemed advisable hereafter to consider *M. exalbescens* Fern. as a subspecies, *M. spicatum* subsp. *exalbescens* (Fern.) Hult.

6. Thus both *M. spicatum* L. and *M. spicatum* subsp. *exalbescens* Hult. go on record for New Jersey, the record for the former being a new one.—BOTANY DEPARTMENT, RUTGERS UNIVERSITY, NEW BRUNSWICK, NEW JERSEY.

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GERMINATION OF SPORES OF ISOETES TUCKERMANI A. BR. IN THEIR NATURAL HABITAT.—Collecting pond plants in Worcester County, Massachusetts, was unusually successful last season, because it was possible to walk over most of an entire pond-bottom and up the bed of the entering stream. Mrs. Gates and I found *Isoetes* at various spots. The plants were much matured with the spores mostly discharged and about the color of the exsiccated muck. In the plant society, among many species, the following were abundant: *Eleocharis Smallii* Britton, mats of *Eleocharis acicularis* (L.) R. & S., *Scirpus Smithii* Gray, forma *setosus* Fernald, *Xyris caroliniana* Walt., *Juncus militaris* Bigl. in relatively deeper depressions, and *Eriocaulon septangulare* With. scattered in shallower areas.

A patch of vivid green on the margin of the dried-out mill pond, marked a stranded concentration of *Isoetes*, green with the first few leaves of a multitude of germinating spores. This green patch covered irregularly some fifteen to twenty square feet, at the southern end of the pond, near, but at one side of the outlet. When flooded to normal highwater, the gentle slope would be roughly a foot below the surface, at the deepest point. A collection of the *Isoetes* was made with the sandy soil of the pond bottom adhering to the mature and fruiting plants. Microscopical examination at the laboratory confirmed the germination and the development of sporelings in all stages, the cracking open of the spores, spores with emerging leaves and rooted plantlets with several leaves, the spore-coat in some instances remaining attached. Myriads of spores speckled the soil.

The species was determined by Mr. Philip G. Meissner as *Isoetes Tuckermani* A. Br. (Hadwen Herbarium sheet 28,524). Dr. Norma E. Pfeiffer of Boyce Thompson Institute has kindly verified the determination (27 April 1954), which is much appreciated. The collection was made 27 September 1953 in Douglas, Massachusetts, at an abandoned mill pond, on the west side of South Street, approximately at the boundary of Burrillville, Rhode Island. The pond was again visited 15 June 1954. It was found at capacity level and the spot where the *Isoetes* had been collected was completely covered. The species could not be found even though a careful search was made.

The apparent absence of *Isoetes* this year may be attributable to the earliness of the season.—BURTON N. GATES,

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SOME NOTES ON THE FLORA OF SOUTHERN ILLINOIS.—While botanizing in southern Illinois during 1953 and the early part of 1954, several plants of unusual occurrence for the area were found. Some of these mark additions to the flora of Illinois while the remainder either are range extensions or new station records.

Unless otherwise stated, all specimens cited are on deposit in the herbarium of Southern Illinois University, Carbondale, Illinois.

ASPLENIUM BRADLEYI Eaton. This rare fern was found growing in crevices in a sandstone bluff. A frond from a large plant was found to have eighteen pairs of pinnae. COLLECTION DATA: crevice of sandstone bluff, along Piney Creek, one mile west of West Point, Randolph County; May 22, 1954. *Mohlenbrock and Voigt 2491*.

CAREX AQUATILIS Wahlenb. This species was found in a clump along a stream in Randolph County. COLLECTION DATA: along Piney Creek, one mile west of West Point, Illinois; April 24, 1954. *Mohlenbrock 2290*.

CAREX TORTA Boott. This recently discovered plant for Illinois has been recorded from several stations. COLLECTION DATA: clumped in a flowing stream, Dixon Springs State Park, Pope County; April 16, 1954. *Mohlenbrock 2057*. Along Rock Creek, four and one-half miles north of Cave-in-Rock, Hardin County; April 17, 1954. *Voigt and Mohlenbrock 2146*. Emerged in Piney Creek, one mile west of West Point, Randolph County; April 24, 1954. *Mohlenbrock 2322*.

JUNCUS DIFFUSISSIMUS Buckl. The diffuse rush, found in the adjacent states of Indiana and Missouri, was collected for the first time in Illinois along a roadside ditch. COLLECTION DATA: wet soil along country road, one-half mile south of Makanda, Giant City State Park, Jackson County; September 19, 1953. *Voigt and Mohlenbrock 1507*.

TRILLIUM RECURVATUM Beck, forma *SHAYI* Palmer & Steyererm. This yellow color-form is found at several sites in a rich mesic woodland at Lake Murphysboro. COLLECTION DATA: rich, mesic woods, Lake Murphysboro, Jackson County; April 23, 1954. *Mohlenbrock 2207*.

RANUNCULUS HARVEYI (Gray) Britt. This species was known previously from southern Missouri, Arkansas, and Alabama. COLLECTION DATA: dry rocky slopes along Piney Creek, one mile west of West Point, Illinois, Randolph County; April 24, 1954. *Mohlenbrock 2316*.

GEUM VIRGINIANUM L. The range of this species formerly extended westward to Indiana. It occurs only sparingly at Giant City State Park. COLLECTION DATA: dry woods, one-fourth mile northeast of the lodge, Giant City State Park, Union County; June 24, 1953. *Mohlenbrock 1594*.

CELASTRUS ORBICULATA Thunb. An escape from cultivation, this bittersweet has become established in Giant City State Park. COLLECTION DATA: wet woods, one-half mile south of county line, Giant City State Park, Union County; June 23, 1953. *Mohlenbrock 292*. Climbing on various trees, roadside, across from stonefort, Giant City State Park, Jackson County; May 10, 1954. *Mohlenbrock 2416*.

The stations for the following plants apparently are extensions of their ranges in Illinois.

CYPERUS LANCASTRIENSIS Porter. This species, first found in Illinois in Massac County in 1949 (*Evers 19952*),¹ was collected in Jackson County in 1953. COLLECTION DATA: moist meadow, near entrance, Giant City State Park, Jackson County; August 20, 1953. *Mohlenbrock 550*.

CYPERUS SCHWEINITZII Torr. Stream bed, Giant City State Park, Jackson County; October 23, 1953. *Mohlenbrock 715*.

CAREX HALEANA Olney. Dry ground in open woods, Giant City State Park, Jackson County; May 15, 1954. *Mohlenbrock 629*.

ROSA BLANDA Ait. Roadside, shaded, Giant City State Park, Union County; May 15, 1954. *Mohlenbrock 66*.

EUPHORBIA OBTUSATA Pursh. Foot of limestone talus slope, Pine Hills, Union County; May 2, 1954. *Mohlenbrock 2417*.

RHUS TYPHINA L. Rich moist woods, Giant City State Park, Jackson County; September 20, 1953. *Mohlenbrock 221*.

HYPERICUM DENTICULATUM Walt. A new station has been found for this species making the second for it in Illinois. It was first collected in Hardin County in 1949 (*Bailey & Swaine 1683*). COLLECTION DATA: wet, shaded woods, Giant City State Park, Jackson County; August 9, 1953. *Mohlenbrock 515*.

CHAEROPHYLLUM TAINTURIERI Hook. Wet soil along State Highway 3, two miles northeast of Gorham, Jackson County; May 14, 1954. *Mohlenbrock and Weber 2668*.

HEDEOMA HISPIDA Pursh. Dry woodland, Giant City State Park, Jackson County; August 25, 1953. *Mohlenbrock 784*.

VIBURNUM LENTAGO L. Edge of woods, Giant City State Park, Jackson County; April 30, 1953. *Mohlenbrock 641*.

BIDENS POLYLEPIS Blake. Wet roadside ditch, Giant City State Park, Jackson County; October 9, 1954. *Mohlenbrock 323*.

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¹ The specimen of *Cyperus lancastris* Porter (*Evers 19952*) is on deposit in the Illinois Natural History Survey Herbarium, Urbana, Illinois.

THE EXTRAORDINARY FUNICULUS OF
ACACIA CONFUSA MERRILL*

THE funiculus is ordinarily a short and simple structure which serves as a stalk for the ovule. As such, it shows little structure and is usually a straight cord, often of very slight length. Because of its simplicity it has largely been neglected. Eames and Mac Daniels (1947) do not mention it, nor does Esau (1953). Netolitzky (1926) discusses the insertion of the funiculus on many seeds but never mentions its vascular structure. Yet it must have sufficient vascular structure to carry the food and water, often large in amount, needed for the growth of the ovule from a minute structure to a comparatively large one, sometimes even a very large one.

In a few species it has been noted that outgrowths of the funiculus have given rise to structures caruncular or arillar, which formerly were supposed to be outgrowths from the seed coats. The *Magnolia* has an unusual funiculus which stretches when the fruits break open and allow the large seeds to fall. For a time the elongated funiculi support the seeds outside the fruits but they soon part and allow the seeds to drop. The funiculus of this plant stretches by the extension of the spiral thickening of the tracheids Prantl (1894).

Bailey (1925) states that the *Acacias* frequently have elongated funiculi, and that the funiculus is found "either twice encircling the seed or bent back upon itself." I had not known of this peculiarity when I observed an *Acacia* (later identified as *Acacia confusa* Merrill), in the plantings of the Federal Experiment Station at Mayaguez, Puerto Rico, which showed brilliant orange threads hanging over it. Examination showed that the ripe pods were breaking open and allowing the seeds to fall. But the fall of the seeds was soon checked by the orange threads which were found to be unusually long funiculi. Some of the seeds remained suspended for days although the greater number became detached within a few hours. Wetting of the structures by rain caused a considerable retraction of the seeds but never enough to pull them back into the fruits. Usually it reduced the distance of the seed from the fruit by about one half. This

* Paper No. 1022 from the Department of Botany, University of Michigan.

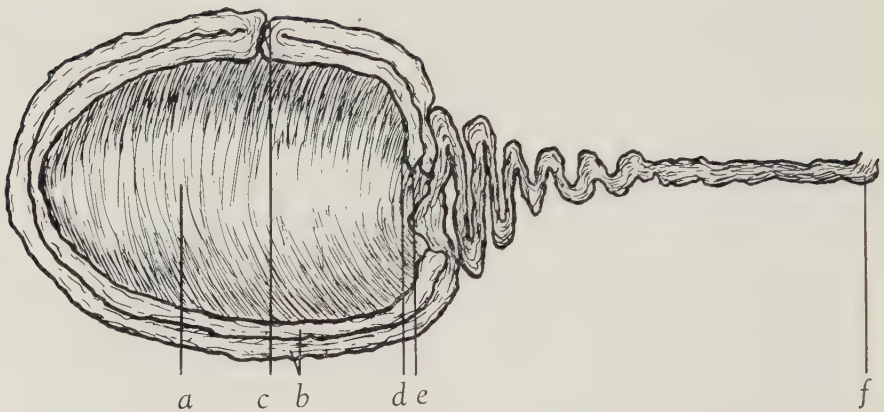


FIGURE 1. A seed of *Acacia confusa* surrounded by two strands of the funiculus; *a*, seed, *b*, two strands of funiculus, *c*, point at which strands of funiculus fold back upon themselves, *d*, micropyle, *e*, hilum of funiculus, *f*, funiculus near attachment to the placenta.

shortening was brought about by further bending and twisting of the funiculus rather than any shrinking of the funicular cells.

The color which first called my attention to the structures was a very rich, bright orange. Nothing is known of it save that 2 months in 85 per cent lactic acid did not fade or clear it to a noticeable degree.

In the fruit the funiculus is very curiously coiled. Near the placenta several sets of reverse curves are formed and then two layers of funiculus are formed around the seed (Fig. 1*a*). But strangely enough this does not mean that two coils pass around the seed. A strand of the funiculus goes about three fourths around the seed then folds sharply backward (Fig. 1*c*) and passes around the seed in the other direction until it meets the fold just described. Now it folds backward and extends to the attachment of the seed. At first I thought to the location of these folds (Fig. 1*c*) came at the micropyle but it does not, for the micropyle is found at the end of the seed (Fig. 1*d*). No explanation for this peculiar folding of the funiculus occurs to me.

The strand of the mature funiculus shows a central thread of xylem surrounded by a loose sleeve of parenchymatous cells. The xylem is made up exclusively of spiral tracheids. The parenchymatous cells have thickened walls which contain the

orange color previously mentioned. They are somewhat elongated in the lengthwise direction of the funiculus but otherwise show no noticeable peculiarities.

A careful study of cross and longitudinal sections of the funicular strand reveals no trace of phloem or any structure which could have resulted from degenerating phloem. Unfortunately, I had only mature tissues, and have no proof that phloem was not present at an earlier stage. If so, its absolutely complete disappearance at maturity is remarkable.—CARL D. LARUE;

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CAREX AENEA FERNALD (TYPICAL) IN COOK COUNTY, MINNESOTA.—During the preparation of the final manuscript of "A floristic study of Cook County, northeastern Minnesota," coauthored by the late Fred K. Butters and me and published in *RHODORA* 55 (1953), the records of *Carex aenea* Fernald (typical) were omitted. Paragraph 2, page 130 of *RHODORA* 55 should read as follows:—

CAREX AENEA Fernald (typical). Proc. Amer. Acad. Arts & Sci. 37: 480. 1902. Perigynia ovate-lanceolate, veinless to moderately veined on the ventral face; achenes ovate. LECTOTYPE, M. L. Fernald, June 8, 1901, gravelly bank, Orono, Maine (in Herb. Gray).—*Lakela* 3646, Jul. 4, 1940, along a path on a rocky ridge, Windigo Point, Sea Gull Lake; *Butters, Burns & Hendrickson* 103, Jul. 11, 1938, top of cliff south of Rove Lake; *Burns & Hendrickson* 155, Jul. 17, 1938, side of cliff just south of portage between Clearwater Lake and West Pike Lake; *Burns & Hendrickson* 407, Aug. 7, 1938, on ledge of cliff, east side of Little Caribou Lake; *Burns & Hendrickson* 380, Aug. 5, 1938, on cliff overlooking west side of Canoe Lake; *Burns & Hendrickson* 383, Aug. 5, 1938, on big cliff, Alder Lake; *Butters, Abbe & Abbe* 270, Jul. 4, 1937, top of ridge on south side and toward west end of Mountain Lake; *Butters, Burns &*

Hendrickson 35, Jul. 7, 1938, top of cliff at west end of Mountain Lake; *Butters, Burns & Hendrickson 57*, Jul. 7, 1938, on rocks along base of cliff at west end and on south side of Mountain Lake; *Butters, Burns & Hendrickson 72*, Jul. 9, 1938, along base of diabase cliff, $\frac{1}{2}$ mile east of east end of Mountain Lake; *Butters, Burns & Hendrickson 86*, Jul. 9, 1938, on cliff, $\frac{1}{2}$ mile east of east end of Mountain Lake; *Burns & Hendrickson 181*, Jul. 20, 1938, cliff $\frac{3}{4}$ mile north of middle of West Pike Lake; *Burns & Hendrickson 239*, Jul. 25, 1938, top of cliff just south of Royal Lake; *Abbe & Abbe 542*, Aug. 19, 1937, Sailboat Island; *Rosendahl 6000*, Aug. 10, 1929, in rocky-sandy soil, beach east of Grand Marais, along Highway No. 1; *Butters & Rosendahl 4467*, Jun. 29, 1924, gravelly soil, along roadside west of Tofte; *Butters, Abbe & Burns 693*, Jul. 1, 1940, cliff on east side of North Fowl Lake (Thunder Bay District, Ont.).—
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